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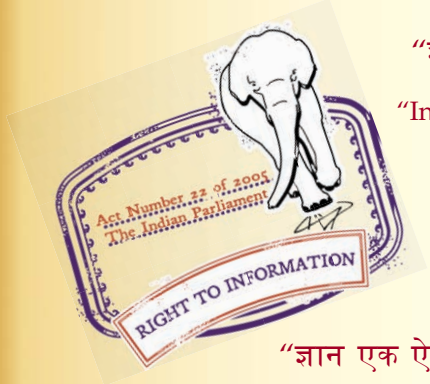

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"Knowledge is such a treasure which cannot be stolen"

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IS : 3231 (Part 3/Sec 5) - 1987

(Reaffirmed 2001)

Indian Standard

SPECIFICATION FOR ELECTRICAL RELAYS FOR POWER SYSTEM PROTECTION

PART 3 REQUIREMENTS FOR PARTICULAR GROUP OF RELAYS

Section 5 Impedance Measuring Relays

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Indian Standard

SPECIFICATION FOR ELECTRICAL RELAYS FOR POWER SYSTEM PROTECTION

PART 3 REQUIREMENTS FOR PARTICULAR GROUP OF RELAYS

Section 5 Impedance Measuring Relays

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Indian Standard

SPECIFICATION FOR ELECTRICAL RELAYS FOR POWER SYSTEM PROTECTION

PART 3 REQUIREMENTS FOR PARTICULAR GROUP OF RELAYS

Section 5 Impedance Measuring Relays

0. FOREWORD

0.1 This Indian Standard (Part 3/Sec 5) was adopted by the Indian Standards Institution on 27 February 1987, after the draft finalized by the Relays Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard is one of the series of standards being brought out to cover requirements of protection relays. General introduction to this series is given in IS : 3231 (Part 0)-1986*.

0.3 According to the classification on hierarchical basis [*see* IS : 3231 (Part 0)-1986*], this standard is a third level document.

0.4 This standard (Part 3/Sec 5) should be read in conjunction with IS : 3231 (Part 2/Sec 2)-1987† to which a reference has been made, as these relays constitute a particular sub-family (group) of measuring relays with more than one input energizing quantity.

0.5 This standard is based on IEC, Publication 255-16 (1982) 'Electrical relays: Part 16 Impedance measuring relays', issued by the International Electrotechnical Commission (IEC).

0.6 For the purpose of deciding whether a particular requirement of this standard is complised with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2 - 1960‡. The number of signifiant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*Specification for electrical relays for power system protection: Part 0 General introduction and list of parts.

†Specification for electrical relays for power system protection: Part 2 Requirements for principal families, Section 2 General requirements for measuring relays.

‡Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This Standard (Part 3/Sec 5) specifies the general requirements for impedance measuring relays. These relays constitute a particular sub-family of measuring relays with more than one input energizing quantity.

1.2 This standard specifies test methods and methods of presenting relay characteristics and performance. It covers multi-input energizing quantity measuring relays in which impedance is a characteristic quantity and for which the operating characteristics are defined in R-X plane.

1.3 This standard applies to independent or dependent specified time relays.

1.4 Relays coming within the scope of IS : 3231 (Part 3/Sec 4)-1987* are excluded.

1.5 This standard applies only to relays in new condition.

NOTE 1 — The term relay includes all the additional components which are necessary for its operation and tested with it.

NOTE 2 — The voltage(s) and/or current(s) contributing to the measurement of the impedance can be either simple quantities or combinations of more than one voltage and/or more than one current, for example, the difference of two phase-to-ground voltage, the sum of a phase current and residual current. To obtain specific operating characteristics which may have special properties (for example, directional), the energizing quantities may be mixed or additional input quantities may be brought into the relay.

2. TERMINOLOGY

2.1 For the purpose of this standard, the following definitions, in addition to those given in IS : 1885 (Part 9)-1986†, shall apply.

2.2 Source Impedance Zs — For a particular fault location, the source impedance is the impedance in the equivalent circuit of the fault current path between the point where the voltage is applied to the measuring relay and the emf in the equivalent circuit producing the fault current in the same path.

NOTE — Where necessary, the source impedance takes into account its positive, negative and zero sequence components.

2.3 Steady-State Characteristic — The characteristic resulting from a slow change in the value of at least one of the input energizing quantities.

2.4 Dynamic Characteristic — The characteristic resulting from a sudden change in the value of at least one of the input energizing quantities, including the effect of any aperiodic component.

*Specification for electrical relays for power system protection: Part 3 Requirements for particular group of relays, Section 4 Directional relays and power relays.

†Electrotechnical vocabulary: Part 9 Electrical relays.

2.5 Transient Characteristic — The characteristic resulting from transient variations in the value of the input energizing quantities, such as magnetizing in-rush current, travelling waves, etc.

3. STANDARD VALUES

3.1 Input and Auxiliary Energizing Quantities and Frequency — The standard values of input and auxiliary energizing quantities and of frequency are specified in IS : 3231 (Part 2/Sec 2)-1987*.

3.1.1 *Effective Range of Input Energizing Quantities* — There are no standard effective ranges of input energizing quantities. These shall be declared by the manufacturer or mutually agreed between the manufacturer and the user.

3.1.2 *Operative Range of Input Energizing Quantities* — The standard values of operative ranges of auxiliary energizing quantities are specified in IS : 3231 (Part 2/Sec 2)-1987*.

3.2 Characteristic Quantity — There are no standard values of the characteristic quantity or of its setting range.

3.3 Specified Times — There are no standard values of specified times.

3.4 Standard Reference Values of Influencing Quantities and Factors, and Standard Values of Their Nominal and Extreme Ranges

3.4.1 *Influencing Quantities and Factors* — The standard reference conditions are given in Table 1 of IS : 3231 (Part 2/Sec 2)-1987*. In addition, the standard conditions specified in Table 1 shall apply to impedance measuring relays.

TABLE 1 STANDARD REFERENCE CONDITIONS AND TEST TOLERANCES OF INFLUENCING QUANTITIES AND FACTORS

	Influencing Quantity or Factor	Reference Condition	Test Tolerance
Characteristic and input energizing quantities	Input energizing voltage(s) Input energizing current(s) Phase angle between input energizing quantities	As declared by the manufacturer or agreed to between the manufacturer and the user, unless specified in this standard or lower level document	
	dc component in ac, transient	Zero, unless specified in this standard (*see* Note)	5 percent of peak ac value
Auxiliary energizing quantities	dc component in ac, transient	Zero (*see* Note)	5 percent of peak ac value

NOTE — In the special case of relays in which polyphase measurements are made on a single relay, the manufacturer shall define which of the input quantities shall be under reference conditions.

*Specification for electrical relays for power system protection: Part 2 Requirements for principal families, Section 2 General requirements for measuring relays.

3.4.2 *Limits of the Nominal Ranges of the Influencing Quantities and Factors* — The standard values are specified in Table 2 of IS : 3231 (Part 2/Sec 2)-1987*. In addition, the standard values specified in Table 2 shall apply to impedance measuring relays.

TABLE 2 STANDARD VALUES OF THE LIMITS OF THE NOMINAL RANGES OF INFLUENCING QUANTITIES AND FACTORS

	Influencing Quantity or Factor	Nominal Range
Characteristic and input energizing quantities	Input energizing voltage(s)	As declared by the manufacturer or agreed to between the manufacturer and the user
	Input energizing current(s)	
	Phase angle between input energizing quantities	
	Frequency	
	Waveform	
	dc component in ac, steady state	
	dc component in ac, transient	
Auxiliary energizing quantities	Voltage or current	As declared by the manufacturer or agreed to between the manufacturer and the user, unless specified in this standard
	Frequency	
	Waveform	
	ac component in dc (ripple)	0 to 12 percent of the rated dc value
	dc component in ac, steady state	As declared by the manufacturer or agreed to between the manufacturer and the user, unless specified in this standard
	dc component in ac, transient	

3.5 Values of the Limits of the Operative Range of the Auxiliary Energizing Quantities — The standard values of the limits of the operative range of the auxiliary energizing quantities are specified in IS : 3231 (Part 2/Sec 2)-1987*.

4. METHODS OF PRESENTING RELAY CHARACTERISTICS AND PERFORMANCE

4.1 Operating Characteristics

4.1.1 The manufacturer shall declare the operating characteristics in the *R-X* plane in graphical form or by mathematical formulae. The operating characteristics shall be referred to the relay impedance setting(s). The exact significance of the setting value shall be defined by

*Specification for electrical relays for power system protection: Part 2 Requirements for principal families, Section 2 General requirements for measuring relays.

the manufacturer, that is, whether it is in terms of the phase or loop impedance. The effect of influencing quantities or factors, such as source impedance, fault direction, type of fault, voltage value, phase angle value, etc, shall also be shown graphically or shall be stated. Typical examples of characteristics used in practice are shown in Fig. 1.

4.1.2 The manufacturer shall declare the temporary and steady output states of the relay when the input voltage is zero, due to either an interruption or a short circuit, over the operating current range of the relay.

4.1.3 If an impedance relay has current-dependent operating values, this influence can be shown in graphical form for different settings with the input current as the varying influencing quantity and at a constant phase angle declared by the manufacturer as shown in Fig. 2. An alternative method of presentation is a plot of the *U-I* characteristic as shown in Fig. 3.

4.1.4 Where the operating characteristics are different for faults in the forward and the reverse direction, the manufacturer shall declare the operating characteristics for both directions of fault current as is shown in Fig. 1E.

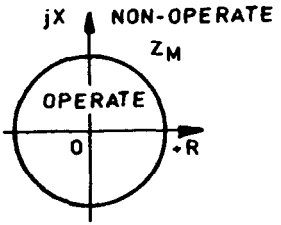
NOTE — The characteristic of some designs of relay may be influenced by the current and/or voltage conditions in the unfaulted phase(s).

4.2 Resetting Characteristics — The resetting characteristic shall be expressed by graphical form with the input current, voltage or phase angle as the varying influencing quantity and the others under reference conditions. If applicable, the resetting characteristic may be expressed as a constant ratio.

4.3 Operating Times — The manufacturer shall declare the operating times either at declared values of source impedance to relay setting ratio, or at declared values of current, and at declared values of impedance within the effective range of the relay.

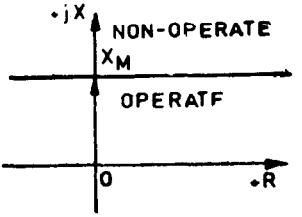
4.3.1 The effect of variation of the ratio of source impedance to relay setting ratio, or of current and of varying values of impedance within the effective range of the relay shall be declared by the manufacturer in graphical form; examples of these forms are shown in Fig. 4, 5 and 6. The relay setting, phase angle and appropriate initial values of the input, energizing quantities shall be declared by the manufacturer.

4.4 Resetting Times — Where relevant, the manufacturer shall declare the resetting times for the appropriate initial and final conditions.



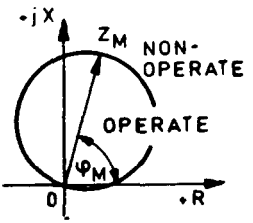
Z_M = Setting impedance

1A CIRCULAR CHARACTERISTIC



X_M = Reactance setting

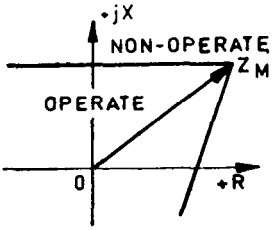
1B REACTANCE CHARACTERISTIC



Z_M = Setting impedance

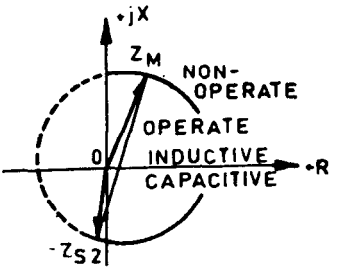
φ_M = Angle of setting impedance

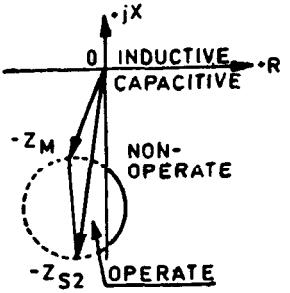
1C CIRCULAR OFFSET CHARACTERISTIC



Z_M = Setting impedance

1D INTERSECTING STRAIGHT LINE CHARACTERISTIC



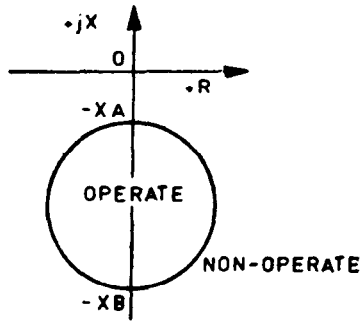


Z_M = Setting impedance

Z_{S_2} = Negative sequence source impedance

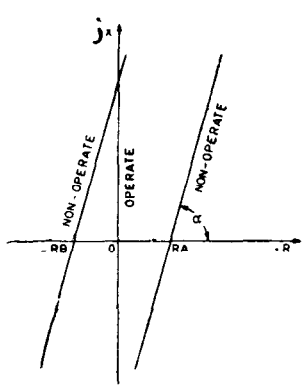
1E CIRCULAR CHARACTERISTIC OF PHASE -TO-PHASE FAULT, FORWARD DIRECTION (LEFT) AND REVERSE DIRECTION (RIGHT)

FIG. 1 EXAMPLES OF OPERATING CHARACTERISTICS OF PARTICULAR TYPES OF RELAYS — *Contd*



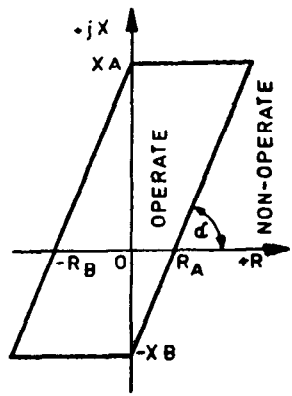
RELAY SETTINGS: XA, XB

1F CIRCULAR OFFSET CHARACTERISTIC



RELAY SETTINGS: R_A, R_B, α

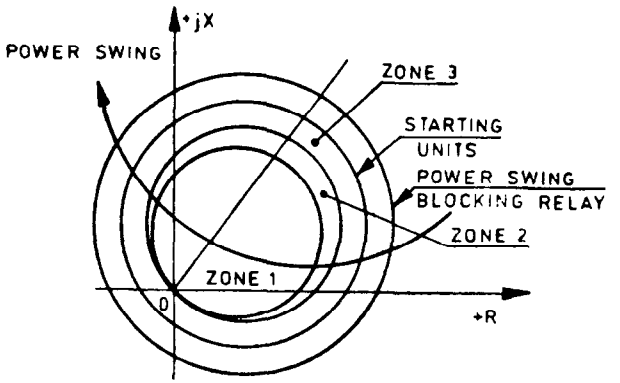
1G STRAIGHT LINES



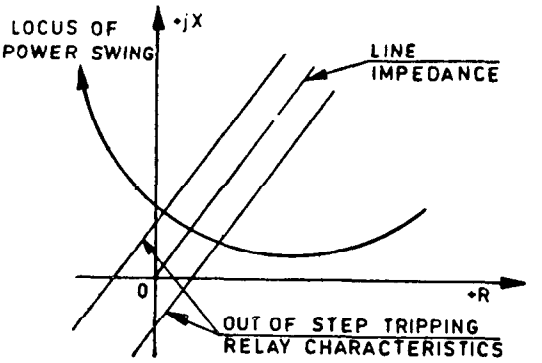
RELAY SETTINGS: R_A, R_B, XA, XB, α

1H PARALLELOGRAM SHADE CHARACTERISTIC

FIG. 1 EXAMPLES OF OPERATING CHARACTERISTICS OF PARTICULAR TYPES OF RELAYS — *Contd*



1J POWER SWING BLOCKING RELAY CHARACTERISTICS



1K OUT OF STEP TRIPPING RELAY CHARACTERISTICS

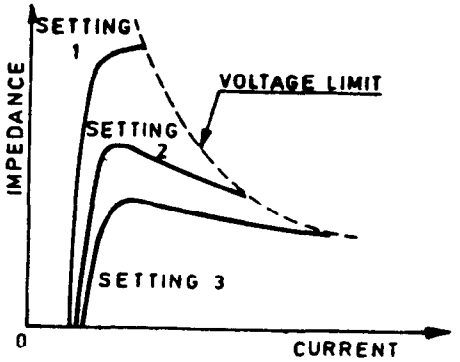
FIG. 1 EXAMPLES OF OPERATING CHARACTERISTICS OF PARTICULAR TYPES OF RELAY

5. THERMAL REQUIREMENTS

5.1 The thermal requirements are specified in IS : 3231 (Part 2/Sec 2)-1987*. In addition, the following requirements shall apply.

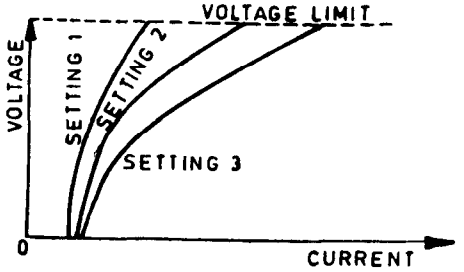
5.1.1 For relays connected to a polyphase system, the continuous thermal withstand current value shall be declared for balanced polyphase currents applied to the appropriate current input circuits and with rated voltage and applied to all the voltage input circuits.

*Specification for electrical relays for power system protection: Part 2 Requirements for principal families, Section 2 General requirements for measuring relays.



Phase angle = Constant value declared by the manufacturer

FIG. 2 OPERATING CHARACTERISTIC $Z = f(I)$



Phase angle = Constant value declared by the manufacturer

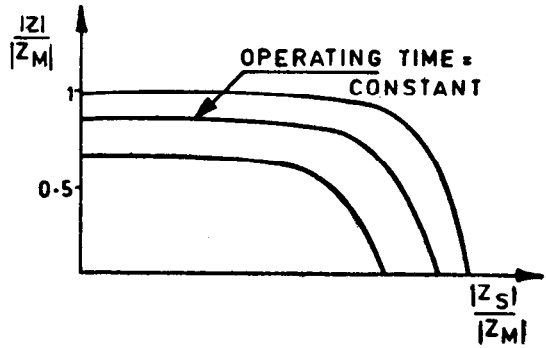
FIG. 3 OPERATING CHARACTERISTIC $U = f(I)$

5.1.2 The continuous thermal withstand voltage value shall be declared for balanced polyphase voltages applied to the appropriate input voltage circuits and with rated current applied to all the current input circuits.

6. ACCURACY

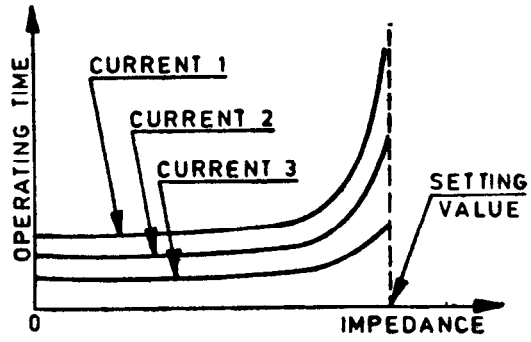
6.1 The manufacturer shall declare the accuracy of the relay as specified in IS : 3231 (Part 2/Sec 2)-1987*. No standard methods for the

*Specification for electrical relays for power system protection: Part 1 Requirements for principal families, Section 2 General requirements for measuring relays.



Phase angle = Constant value declared by the manufacturer
Z_S = Source impedance
Z_M = Relay impedance setting
Z = Impedance to be measured by the relay

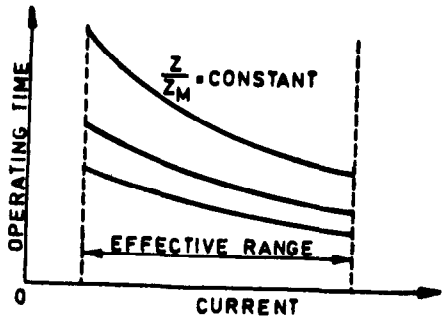
FIG. 4 CONSTANT TIME CURVES



Phase angle = Constant value declared by the manufacturer

FIG. 5 OPERATING TIME UNDER REFERENCE CONDITIONS

declaration of accuracy or for the determination of errors are at present specified. There are many factors which may influence the accuracy of impedance measuring relays. Typical influencing factors are the magnitude and phase of input energizing currents and voltages, magnitude and time constant of the dc (aperiodic) component in the input energizing quantities, transient components in the input energizing voltages, and currents, frequency, magnitude and phase of polarizing voltages or currents, etc. In view of the complex effects of these and other influencing factors, no standard requirements concerning variations are at present specified.



Phase angle = Constant value declared by the manufacturer
Z_M = Relay impedance setting
Z = Impedance to be measured by the relay

FIG. 6 OPERATING TIME UNDER REFERENCE CONDITIONS

6.2 If variations due to a particular influencing factor are presented by the manufacturer, he shall declare the method of presentation and the conditions under which these variations were determined.

7. MECHANICAL REQUIREMENTS

7.1 The relevant provisions of IS : 3231 (Part 2/Sec 2)-1987* shall be applicable.

8. RATED BURDEN

8.1 The relevant provisions of IS : 3231 (Part 2/Sec 2)-1987* shall be applicable.

9. SHOCK AND VIBRATION

9.1 The relevant provisions of IS : 3231 (Part 2/Sec 2)-1987* shall be applicable.

10. CONTACT PERFORMANCE

10.1 For relays with contact outputs, the contact requirements of IS : 3231 (Part 1/Sec 1)-1986* shall apply.

11. INSULATION REQUIREMENTS

11.1 The insulation requirements shall be in accordance with IS : 3231 (Part 1/Sec 2)-1986*.

*Specification for electrical relays for power system protection
Part 1 General requirements, Section 1 Contact performance.
Part 1 General requirements, Section 2 Insulation tests.
Part 2 Requirements for principal families, Section 2 General requirements for measuring relays.

12. CONSTRUCTIONAL REQUIREMENTS

12.1 The relevant provisions of IS : 3231 (Part 2/Sec 2)-1987* shall be applicable.

13. HIGH-FREQUENCY DISTURBANCE TESTS

13.1 Where specified for static relays, the requirements for high-frequency disturbance tests specified in IS : 3231 (Part 1/Sec 3)-1986* shall be applicable.

14. MARKING AND DATA

14.1 The marking and data requirements shall be as specified in IS : 3231 (Part 2/Sec 2)-1987*.

15. TESTS

15.1 General

15.1.1 All tests specified in this standard are type tests. The routine tests shall be in accordance with **12.1** of IS : 3231 (Part 2/Sec 2)-1987*.

15.1.2 Unless otherwise specified, the test methods shall be as given in **15.2** to **15.4**.

15.1.3 All influencing quantities and factors shall be at their reference values (within the specified test tolerances), unless otherwise stated in this standard.

15.1.4 The auxiliary energizing quantities shall be at their rated values, unless otherwise specified in this standard.

15.1.5 The input energizing quantities shall be applied or changed suddenly, unless otherwise stated in this standard or by the manufacturer.

15.1.6 Two test conditions are at present considered:

a) Test condition T_1 for determining the steady state characteristics, and

b) Test condition T_2 for determining the dynamic characteristics, including the effect of any transient dc (aperiodic) component. Test conditions for determining the transient characteristics are not at present considered.

15.1.7 For type testing for condition T_2, point-on-wave switching control is preferred. If point-on-wave is used, switching angles covering

*Specification for electrical relays for power system protection:

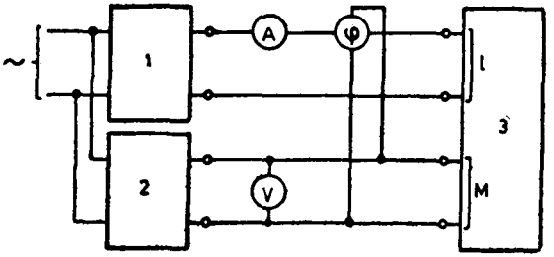
Part 1 General requirements, Section 3 High frequency disturbance test for static relays.

Part 2 Requirements for principal families, Section 2 General requirements for measuring relays.

the range 0 to 360° shall be applied. The X/R ratio, or range of X/R ratios, of the actual test circuit shall be declared by the manufacturer.

15.2 Test Circuits and Methods for Determining Relay Characteristics, Performance and Accuracy

15.2.1 *Tests for Determining Steady State Characteristics* — Figure 7 shows an example of a single-phase test circuit suitable for the determination of the steady state operating characteristics. The phase angle may be varied from 0 to 360°. The actual impedance being measured



1 = Adjustable current source
2 = Adjustable voltage source with phase shifting 0 to 360°
3 = Relay under test

FIG. 7 EXAMPLE OF SINGLE-PHASE TEST CIRCUIT FOR DETERMINING STEADY-STATE CHARACTERISTICS

by the relays shall be calculated from the voltage and the current. One of the input energizing quantities shall be applied with a constant value within its effective range. The other input energizing quantity and the phase angle shall be varied to determine the operate and non-operate levels. It shall be ensured that the waveforms applied to the relay are kept within the prescribed test tolerances; for some designs of relays, stringent tolerances may be required. The circuit for the application of an additional input quantity, if any, shall be declared by the manufacturer. Often it will be necessary to provide a three-phase voltage source and suitable test circuit.

NOTE — Test circuit in Fig. 7 is only typical. Actual test circuit may be decided by the manufacturer and the user by mutual agreement.

15.2.2 *Tests for Determining the Dynamic Characteristics and Operating Times* — Figure 8 shows an example of a single-phase test circuit suitable for the determination of the dynamic characteristic and operating times of a relay. The values of the current and voltage applied to the relay can be set directly by adjustment of the impedance 4. The applied current and corresponding voltage are then defined for a given value of source impedance. Depending on how switch 5a is connected to the relay by means of a link 6, either the full open circuit voltage or zero voltage is applied to the relay before the test. For a given test conditions point-on-

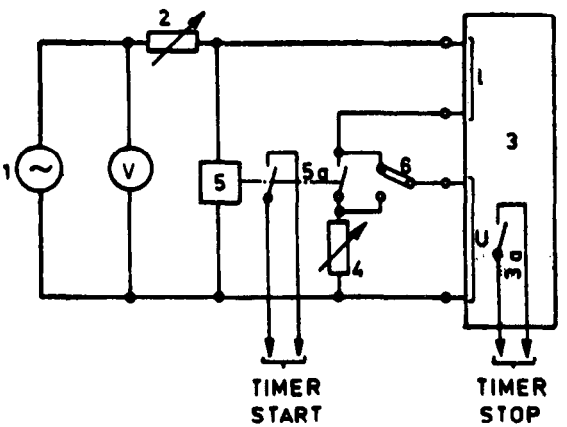
wave switching control governs the magnitude of the transient dc (aperiodic) component in the input current.

Other test circuits giving the same testing conditions are permissible.

It shall be ensured that the waveforms of the sinusoidal input quantities at reference conditions are kept within the prescribed test tolerances; for some designs of relay, stringent tolerances may be required. The circuitry for application of an additional input quantity, if any, shall be declared by the manufacturer. Often it will be necessary to provide a three-phase voltage source and suitable test circuit.

15.3 Thermal Tests — The tests for thermal requirements shall be performed in accordance with IS : 3231 (Part 2/Sec 2)-1987*.

15.4 Mechanical Tests — These tests shall be performed in accordance with IS : 3231 (Part 2/Sec 2)-1987*.



1 = Fixed voltage source
2 = Adjustable source impedance Zs
3 = Relay under test
3a = Output contact
4 = Adjustable impedance Zs to be measured by the Relay
5 = Point-on-wave Switching control device
5a = Switch for sudden application of the Input energizing quantities
6 = Changeover link

FIG. 8 EXAMPLE OF SINGLE-PHASE TEST CIRCUIT FOR DETERMINING DYNAMIC AND OPERATING TIME CHARACTERISTICS

*Specification for electrical relays for power system protection: Part 2 Requirements for principal families, Section 2 General requirements for measuring relays.

BUREAU OF INDIAN STANDARDS

Headquarters:
Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002
Telephones: 323 0131, 323 3375, 323 9402
Fax : 91 11 3234062, 91 11 3239399, 91 11 3239382

Telegrams : Manaksanstha
(Common to all Offices)

Central Laboratory:	Telephone
Plot No. 20/9, Site IV, Sahibabad Industrial Area, Sahibabad 201010	8-77 00 32
Regional Offices:	
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002	323 76 17
*Eastern : 1/14 CIT Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054	337 86 62
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*Sales Office is at 5 Chowringhee Approach, P.O. Princep Street, CALCUTTA 700072	27 10 85
†Sales Office is at Novelty Chambers, Grant Road, MUMBAI 400007	309 65 28
‡Sales Office is at 'F' Block, Unity Building, Narashimaraja Square, BANGALORE 560002	222 39 71

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